Factors Affecting Larval Migration of the Gypsy Moth

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The gypsy moth, *Porthetria dispar* (L.) is a serious economic pest of New England woodlands because of the defoliation caused by the larvae. The severity of defoliation is in part associated with the migration of the larvae. Consequently, study of factors which influence larval migration is important, and more information is necessary to understand the ecology of the insect.

In 1896 Forbush and Fernald described the positive phototrophism of young gypsy moth larvae, and associated it with practical problems of distribution. Much later, in 1930, in a study of larval behavior, de Lepiney described a stimulation of migratory activity by light and a strong negative geotrophism of the larvae. However, it was not until 1947 that a practical relationship between migratory activity and differences in the amount of defoliation in forest sites was suggested by Bess, Spurr and Littlefield. They reported that in certain forest conditions the larvae migrated down from the woodland canopy into the litter and forest understory where the larvae were more susceptible to predation by small mammals. Under other conditions the larvae did not migrate, but remained in the canopy. Bess and coworkers (1947) suggested that the larvae migrated down into the litter and understory seeking cool moist places in which to rest and pupate. Because of these very interesting observations, when the present study of gypsy moth ecology was initiated in 1953, special attention was given to factors involved in larval migration, and its relationship to defoliation.

Laboratory studies

One of the first goals of this study was to determine experimentally whether larvae exhibited a preference for moist sites, or any tendency to migrate toward such sites in which to rest between feeding periods. This was accomplished by utilizing techniques which permitted observation of larval migration in relation to this factor and others—such as food sources providing olfactory stimuli, the influence of geotrophism, and the effect of light. Tubular plastic cylinders, four inches in diameter, one, two and three feet long, were constructed with an access hatch in the center and both open ends covered with 56 gauge nylon netting. Groups of both laboratory reared and field collected larvae in each larval instar were tested for moisture attraction by placing from 10 to 100 larvae in each cylinder with a moisture gradient. When the laboratory relative humidity was lowered to 30 ± 10 per cent and a wet pad was placed at the bottom end of the cylinder (with the lower end capped and the upper end left open) there was a moist site at one end and a dry one at the other. Larvae were placed in the cylinder through the middle hatch and the direction of their migration observed. Test cylinders of various lengths provided different distances from the wet and dry sites.

For single factor tests of moisture the cylinders were placed in a horizontal position in the presence of balanced light intensity at either end. One hour later the numbers of larvae distributed on the wet and dry side of the middle were counted. Groups composed of each five larval instars were tested and each test replicated three times to rule out chance observations.

This procedure was then repeated with fresh young red oak leaves as a test attractant in place of the moist site. This was followed by substituting a strong light (reflected sunlight intensity, projected through a 1 cm. aperture) at one end of the cyinder.

Tests for interaction of factors and for the effect of geotrophism were conducted by rotating the test cylinders from a horizontal to a vertical position. Thus, first instar larvae exhibiting a negative geotrophism migrated to the dry end when it was in the up position.

In these tests it was found that larvae migrated toward a moist site only when responding to another interacting factor (such as light) or when exhibiting a negative geotrophic response. When test cylinders were in the horizontal position, larvae were randomly distributed between the wet and the dry ends. First and second instar larvae migrated to the moist end of the tube only when it was in the up position of the vertical tests. When the cylinders were inverted, the larvae then migrated to the dry ends which were in the up position. Middle and late instar larvae lost the geotrophic orientation and were distributed randomly within the cylinders regardless of the position of the moist sites. Similar responses were observed when light was substituted as a factor in tests with moist sites, except that young larvae migrated toward light even when it was at the bottom of the cylinders and older instar larvae moved away from the lighted end regardless of whether it was in the up or down position. The positive phototrophism of the young larvae and the avoidance of light by the older larvae were exhibited regardless of the position of moisture in the tube.

The responses to the presence of oak leaves in the tests were similar to those observed with moisture. The food alone elicited no migratory responses, but once food was encountered during random ambulatory movements or in the course of migration stimulated by other factors (light, negative geotrophism) larvae accumulated on the leaves and fed.

Field Study

Study of larval responses was conducted in field experiments at Bethany, Connecticut, in the spring of 1956. A number of trees were selected in various sites within an area of woodland where a high population of gypsy moth larvae existed. The trunks of six red oak trees, and low vertical branches were treated with pairs of four inch rings of *Tree Tanglefoot* covered with loose burlap bands. Thus, larvae travelling up the tree trunks were trapped under the lower bands and those moving down the trunks were trapped under the upper bands. The study area was observed daily during the larval growing season and at bi-weekly intervals larvae trapped under the bands.

Results of field studies were similar to those observed in the laboratory. During the first three-week period almost all of the young larvae trapped under the burlap bands were under lower band, indicating movement upward on the tree trunk. Only occasional young larvae were encountered under the upper bands. However, during the second three-week period when larvae were in later instars, increasing numbers were found trapped under the upper band. By the time the trees had been defoliated and first pupae began to appear, almost equal numbers of late instar larvae were found under the upper and lower bands.

Discussion

The study of factors affecting migration of the gypsy moth larvae is perhaps one of the most fascinating problems confronting insect ecologists in New England. In this problem results of laboratory tests show how larvae react and when this information is applied to migration in the field, it helps explain the movements of the larvae between the forest canopy and understory. While one of the obvious factors which might attract the larvae to the understory is the presence of cool moist places it provides for resting and pupation, the results of this study show that migrations of the larvae are considerably more complicated and a response to any one factor such as moisture. In the laboratory, larvae did not migrate toward moist sites unless some other factor was interacting with the moisture. This was difficult to see in field studies, but in the laboratory manipulation of single factors, both alone and against each other, the importance of interacting factors was demonstrated. In tests conducted in darkness, young larvae exhibited a negative geotrophism and migrated upward. Both food and moisture were encountered when they were located at the top of test cylinders. However, when food and moisture were at the bottom, the larvae migrated away from them unless light was added to the bottom. Then the larvae migrated toward the light, overcoming their negative geotrophism. Thus, it was shown that the upward surge of young larvae was a summation of the reactions to these two factors—and that light was the stronger of the two. Complications arose, however, as the definitive responses which the young larvae exhibited were lost by older larvae. The late instar larvae no longer migrated upward in the dark and lost their positive phototrophism. Essentially there was a reversal of the earlier reactions which resulted in downward movement of larvae. At the present time it is not clear if this was a result of a loss of negative geotrophism and the development of an avoidance of light, or whether the larvae developed an avoidance reaction to the heat which was associated with the light. In 1930 de Lepiney described the stimulation of resting larvae by direct sunlight. This movement resembled an avoidance reaction similar to the activity exhibited in the present experiments by late instar larvae in test cylinders, and to the activity observed in field experiments where the avoidance of light was associated with larvae migrating down out of the trees. There is a possibility that an additional factor is involved—a "hunger drive" brought about by heat from the sun increasing the metabolic activity of the larvae. Further study is necessary of the influence of heat and light on the movement of late instar larvae to determine which factor or factors elicits their avoidance reaction and downward migration. The observation of Bess *et al.* (1947) that larvae did not migrate down from the forest canopy where there was no moist understory is not explained in this study. However, it is suggested that the change in response of older larvae may be involved. Therefore, the entire story of migration by gypsy moth larvae is not settled and further study is necessary.

Summary

Laboratory tests were conducted in which the manipulation of plastic cylinders was utilized to determine the effect of food, moisture, light and geotrophism on migratory activity of gypsy moth larvae. Food was encountered primarily in the process of migration stimulated by these factors and the larvae exhibited no indication of being attracted by it alone. Likewise, no attraction or tendency of the larvae to migrate toward moisture could be observed in laboratory experiments except, as in the case with food, when the larvae were responding to the influence

of other factors. Early instar larvae exhibited the strong phototrophic response described by Forbush and Fernald and the negative geotrophic reaction reported by deLepiney. However, in both field and laboratory tests the migratory movements of late instar larvae appeared quite different from those of young larvae. For this reason, it is necessary to consider larval age and the influence of interacting factors when larval migratory activity is under study.

References Cited

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An Unusual Occurrence of Rhinoceros Beetles, (Scarabaeidae Dynastes tityus Linn.)

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The following record of occurrence in considerable numbers of the Rhinoceros beetle (*Dynastes tityus* Linn.) seems worthy of note. Recently a male and female rhinoceros beetle were received at the State Museum from Mr. Wade Lewis, a student of entomology, who collected them at Thurmond, Surry County, North Carolina on March 10, 1959, "in an old rotten stump of an oak tree." The unusual thing about this is that 62 adults were found in the one stump, the sexual ratio being 31 males and 31 females. Literature on this beetle reveals little in regard to population numbers and sex ratios. I have never found over one or two specimens of this beetle at any one time in all the years of my collecting. Thurmond, North Carolina, is situated on the eastern slope of the base of the Blue Ridge Mountains and hardwoods abound in this area favoring a good habitat for Dynastes.